Technical Memorandum No. 33-152

A Standard Chassis for Ground Support Equipment

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ABSTRACT

This memorandum describes the mechanical design of a versatile rack mounted chassis on which numerous different types of both common and special purpose components may be mounted. Photographs of the chassis and its associated parts are included along with examples illustrating the adaptability of the concepts which have been developed.

A standard, low-cost chassis has been fabricated as a result of this design effort which has proven the flexibility of the system, the feasibility of stocking standard parts, the acceptability of minimum documentation, and the ease with which documentation changes may be accomplished. By using this design, electronic engineers are relieved of the extensive mechanical details pertaining to the packaging of their equipment. Also, they are no longer subjected to prolonged drafting periods, excessive documentation, and the uncertainties of long-term procurement of similar commercial items.

I. INTRODUCTION

Ground support equipment (GSE) has become a necessity in testing almost every electronic system. Normally, very little development time is allocated to the design of GSE. To compensate, it is necessary to use more sophisticated design approaches and to perform extensive advance planning to eliminate or, at least, reduce the associated problems. By standardizing some of the features of the design, to meet some of the basic requirements of a ground support equipment system, more effort can be directed toward the details of the design, which are peculiar to a particular system.

This memorandum discusses the design of a GSE chassis and the manner in which standardization has helped to improve the development of present ground support equipment systems.

II. THE PROBLEM

The mechanical packaging of electronic parts is one of the recurrent problems which has been prevalent in those prototype electronic development areas where only a small number of systems are required. In many programs, the electronic circuitry is in a form such as to make it unsuitable for packaging in a manner similar to that used in other programs, or as it quite often happens, problems with packaging techniques used in previous systems have dictated a need for a change. Unfortunately, due to specialization, lack of manpower, and pressing schedules, electronic engineers are frequently assigned the responsibility for packaging the circuitry they develop. Since, as a rule, they are not specialists in packaging, problems which would be obvious to the specialist may be overlooked by the engineer, or he may devote excessive time to this particular phase of the project, time better spent developing and testing the electronics for which he is responsible. Frequently, systems so developed contain individualized and expensively produced parts, but they are not necessarily models of the optimum level of electronic design. Furthermore, vast numbers of drawing are produced for each program which take months to generate, but only in a few instances do these drawings find application in other programs.

As to cost, since in prototype work few systems are to be produced, the per-item cost is high. Errors in design and/or drafting, which cause delay, are usually not discovered until the prototype items are fabricated and since additional items are seldom required, the benefits normally derived by correcting the errors are not realized.

All of the problems associated with the current packaging approach normally occur at a period in the schedule when time is extremely valuable. To accommodate any delay at this time, the system must be compromised.

To summarize the problems which have been experienced in the design of prototype systems:

1. Electronic engineers are doing the mechanical design of electronic packaging.
2. Each engineer has his individual packaging concepts.
3. Vast numbers of drawings are produced to support all the different mechanical designs.
4. Considerable time is consumed in producing mechanical drawings.
5. Design and drafting errors prolong delivery time of parts at crucial periods and the electronic engineer is required to expend his valuable time correcting these mishaps.
6. Few programs use packaging concepts developed on previous programs.
7. The cost of prototype parts is extremely high.
8. The electronic design and testing is compromised due to commitments of the electronic engineer's efforts in the mechanical design of his equipment.

Despite all these obvious disadvantages, many systems are produced in just this manner.

III. THE SOLUTION

The solution was to design a chassis which would mount both specialized and commercial electronic circuitry and be adaptable, to a certain extent, to enable each electronic engineer to accommodate his circuitry or allow him, by some simple method, to make appropriate changes. Primarily, the goals for the design were:

1. A basic chassis to mount:
   a. Electronic logic card files (to hold commercial cards)
   b. Electronic, special purpose, card file (to hold cards with medium weight and medium size components)
   c. Subchassis
   d. Connectors for external cabling
   e. Cabling for internal chassis connectors
   f. Control panels
2. A method for accommodating various different types of card files, subassemblies, connectors, and panels.
3. A design independent of commercial items, as much as possible, because of procurement problems.
4. A set of drawings that would allow rapid fabrication of required parts.
5. A set of drawings that could be easily modified by an electronic engineer. (Drawing changes or new drawings should be producible within a few hours instead of the weeks usually required.)
6. Fabrication of many standard parts at low cost.
7. A stock of standard parts.

All of these goals have been achieved. The philosophy has been not to standardize completely, since it is not feasible to maintain a large stock of general purpose parts for prototype equipment. (Too much standardization is as undesirable as too little.) Instead, certain items are stocked which can be used as designed, while other items are stocked which can be used pending some minor modifications. Drawings which can be easily adapted to a particular requirement are available so that similar parts, using standard techniques, may be fabricated as required.

IV. DESCRIPTION

Figures 1, 2, 3, and 4 show the standard chassis with examples of the various types of parts that can be mounted on the chassis and the manner in which they may be assembled. Table 1 lists all the drawings associated with the standard chassis. (The Appendix provides examples showing how modifications may be made to the existing standard chassis drawings.) A detailed description of the various parts which compose this design follows:

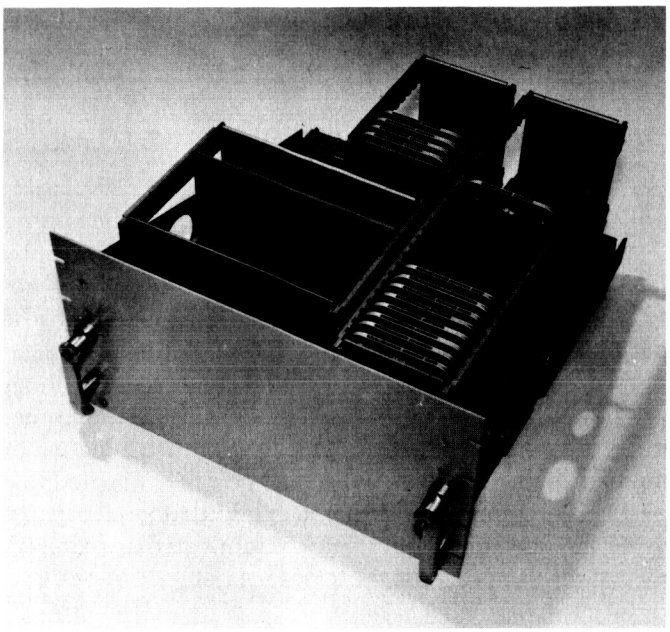

Fig. 1. Standard chassis, front view

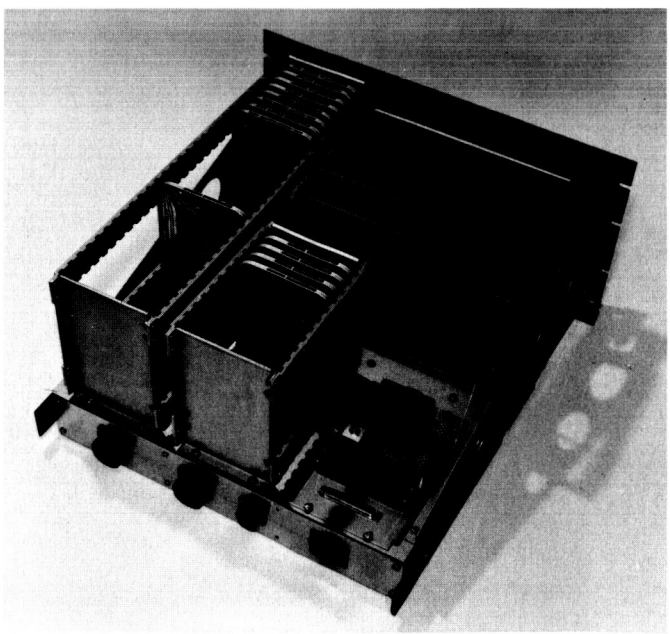

Fig. 2. Standard chassis, rear view

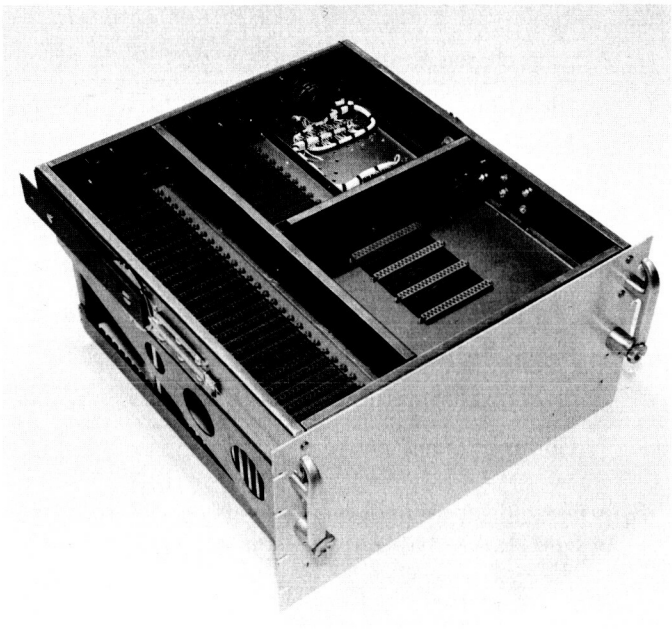

Fig. 3. Standard chassis, bottom view

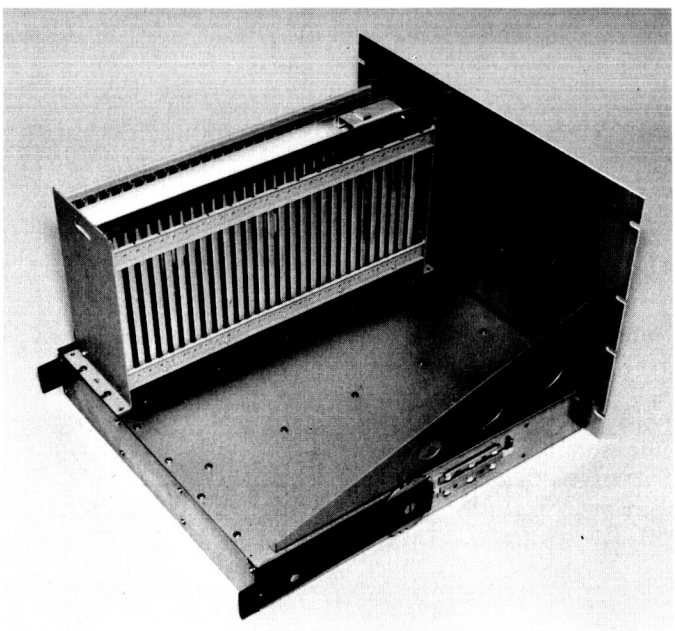

Fig. 4. Standard chassis with commercial logic card file

A. Basic Chassis

Parts for the standard chassis are shown in Fig. 5, while Fig. 6 illustrates the different slides that may be used to adapt the chassis for use as an electronic drawer in a console. The rear panel is produced as a blank so that connector holes of the type and quantity desired may be made to suit the particular chassis requirements. Bendix pygmy connectors are recommended because of their reliability, quick disconnect feature, and their standardization as spacecraft ground support equipment (GSE) connectors. An elapsed time meter may also be mounted on the rear panel to record the total time power is applied to the chassis.

Table 1. Drawing List

Item	Drawing Number	Title
1	B123124	Mount, rail, standard 19" chassis
2	D123125	Side panel, standard 19" chassis
3	D123126	Deck, standard 19" chassis
4	D123127	Gusset, standard 19" chassis
5	D123128	Rail, standard 19" chassis
6	D123129	Rear panel, standard 19" chassis
7	D123140	Rail guide, card file (logic)
8	D123141	End plate, card file (logic)
9	D123154	Card holder assembly
10	D123155	Rail guide, card file (special purpose)
11	D123156	Support end, card holder (special purpose)
12	D123157	Terminal board, blank (special purpose)
13	D123158	Stiffener, terminal board (special purpose)
14	D123159	Sub-chassis
15	J123214	Standard chassis assembly
16	B123215	Spacer

In Fig. 7 a basic chassis is shown using a rear panel mounted at the front to act as a support for a control panel. Connectors can be mounted to the rail to allow the front panel to be disconnected from the chassis. A basic chassis with a recessed control panel support is shown in Fig. 8.

Rails are required to support the deck and are designed for maximum length as supports from front to rear of the chassis; however, they may be shortened to accommodate other arrangements as shown in Fig. 3. This may be accomplished by removing some of the material from one end and redrilling the end holes for the bracket. Oversized holes on the bracket facilitate the mating of the rail with the bracket. Circular holes may be punched in the rails to allow cable access between parts of the chassis separated by the rail. The cable should be protected from the sharp edges of this hole in some manner. Deck plates are machined, as required, to mount card files, subassemblies, and special items.

Gussets are used to support control panels which exceed 5¼ in. in height. Openings are provided in the gussets to admit air from the sides for the purpose of cooling the electronic components. Whenever a panel is used as a support behind the control panel, spacers must be placed in the opening between the control panel and the gussets. To facilitate the rapid assembly of the chassis, on which electronic components may be mounted, the list

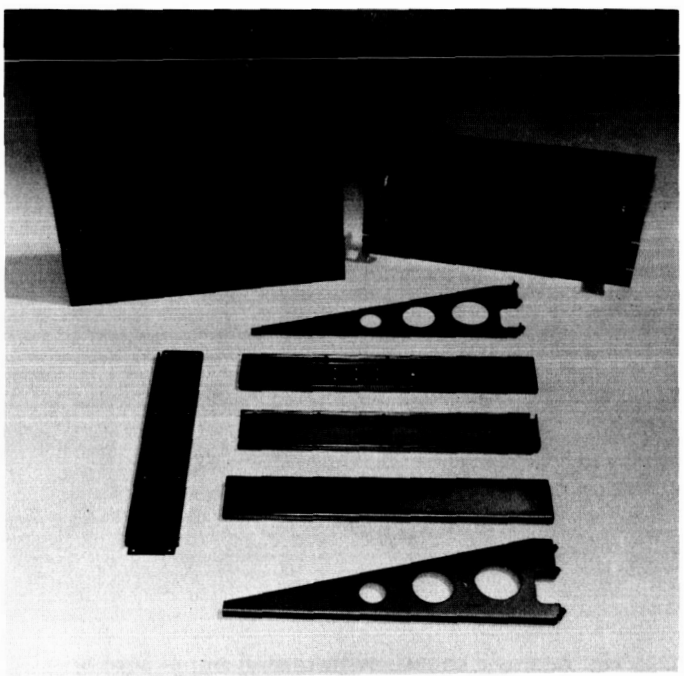

Fig. 5. Standard chassis, basic parts

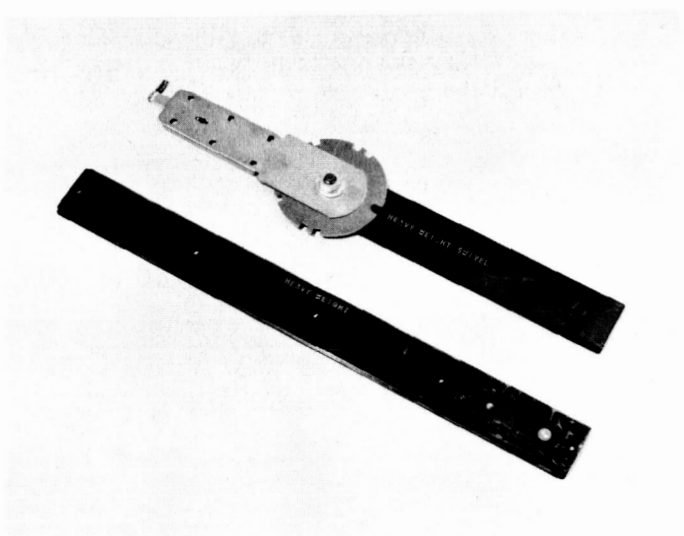

Fig. 6. Standard chassis slides

of items specified in Table 2 should be stored in the quantities dictated by the requirements of the project.

B. Card Files (Logic Cards)

The type of card file that can be mounted on the standard chassis is shown in Fig. 9. Commercial card files (Fig. 4) can be used in place of the files which have been developed for the standard chassis, although commercial files usually have the disadvantage of consuming the entire length of the chassis. This is an unfavorable condition when space is required behind the control panel for mounting components or when an entire file is not completely filled with cards and valuable chassis space has to be wasted.

The standard card file consists of four rails and two end plates as shown by Fig. 10. Rails are slotted for the particular type logic card required. It is possible to have several varieties of logic cards located in the same file if only the thickness of the card varies and the difference in

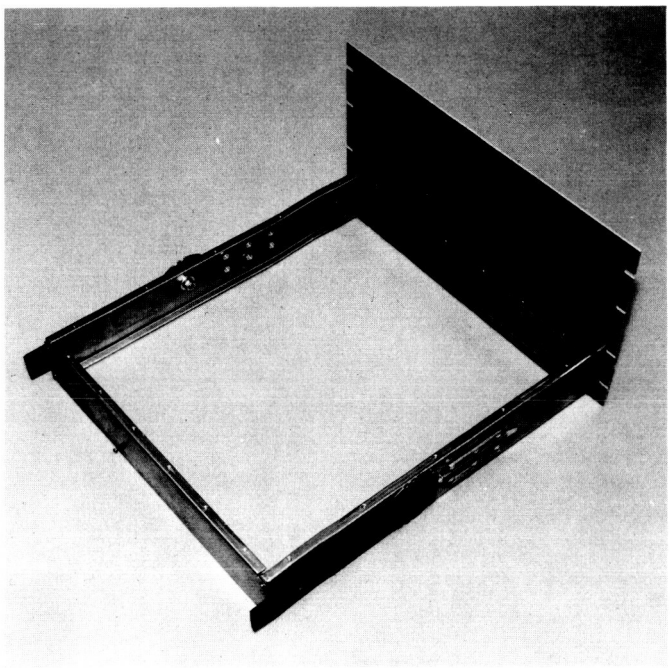

Fig. 7. Basic chassis with control panel support

Table 2. Stock List

Item	Quantity (per chassis)	Drawing number	Title
1	1 pair	D123125	Side panel, standard 19" chassis
2	2	D123129	Rear panel, standard 19" chassis
3	3	D123128	Rail, standard 19" chassis
4	6	B123124	Mount, rail, standard 19" chassis
5	1	D123126	Deck, standard 19" chassis
6	1 pair	D123127	Gusset, standard 19" chassis
7	4	B123215-2	Spacers
8	1		Front panel
9	2		Control panel handles
10	1 pair		Slides

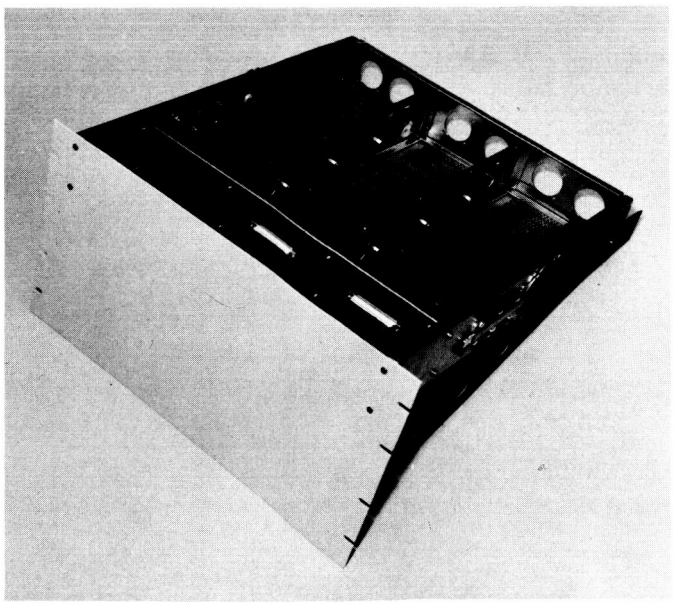

Fig. 8. Basic chassis with recessed control panel support

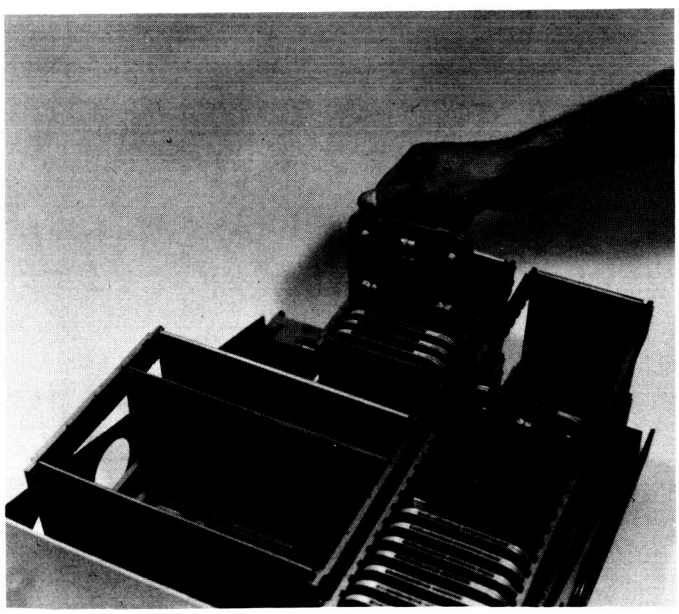

Fig. 9. Standard chassis logic card file

within reasonable limits. The logic card connectors on the deck may also be readily changed.

Since the number of cards required may vary from chassis to chassis, the size of the card file need only be long enough to accommodate the number of cards necessary for the particular application. Thus, if only a small number of logic cards are required valuable chassis space

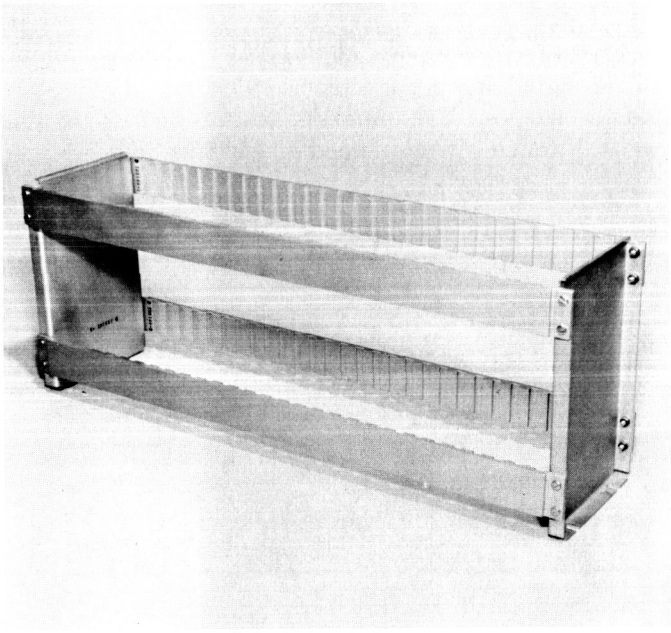

Fig. 10. Standard card file, logic cards

is not occupied by the unused file. The sides of the file are open to facilitate the flow of air between the cards.

The dimensions of the card file may vary for different applications. To accommodate this change, a dash number must be added to the standard drawings for the card file to produce drawings for the new parts as explained in the Appendix.

C. *Card Files (Special Purpose)*

The special purpose card file mounted on the standard chassis is shown in Fig. 11. The special purpose card was designed to mount heavier components and components of considerable size. Normally, these types of components could not be suitably mounted on the logic cards, previously described, nor would they be of such weight or size to warrant mounting on a subchassis.

The special purpose card file (Fig. 12) consists of four rails and two end plates and is similar in nature to the logic card file previously described. The card (Fig. 13) is rigid—the terminal board being mounted on a metal plate —and is capable of supporting such items as relays, large diodes, transistors, capacitors, small transformers, toroids, and other items of a similar nature.

Unlike the rails for the logic card, the rails for the special purpose card are slotted for a particular thickness

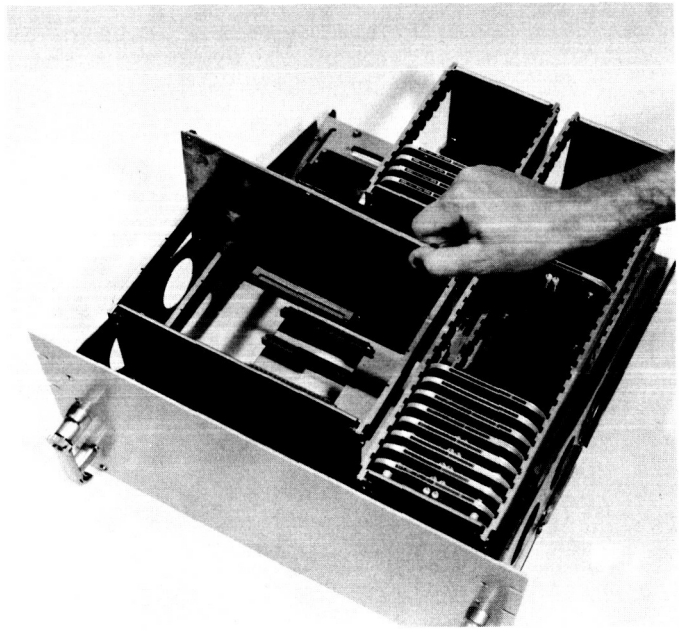

Fig. 11. Standard chassis special purpose card file

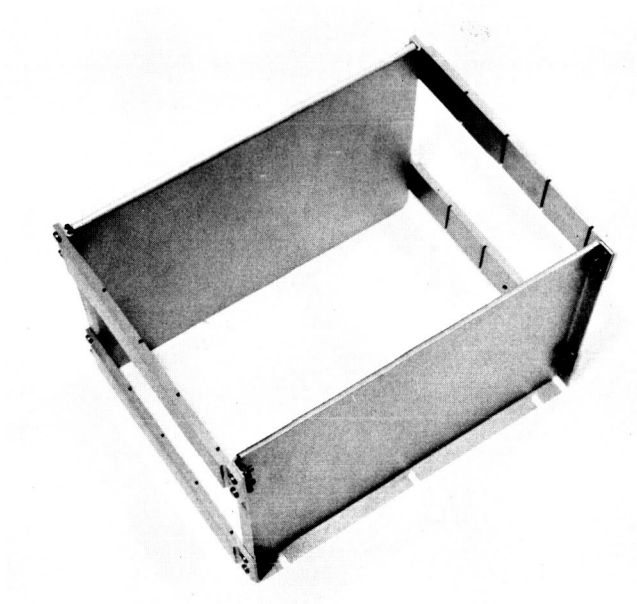

Fig. 12. Standard card file, special purpose

plate; however, the length of the file, the number of cards, their height and width, and the distance between them may be varied for the particular application. The sides of the file are purposely left open to facilitate the flow of air between the cards.

To accommodate changes to the card and card file, dash numbers must be added to the standard drawings for the special purpose card and card file to produce drawings for the new parts, as explained in the Appendix.

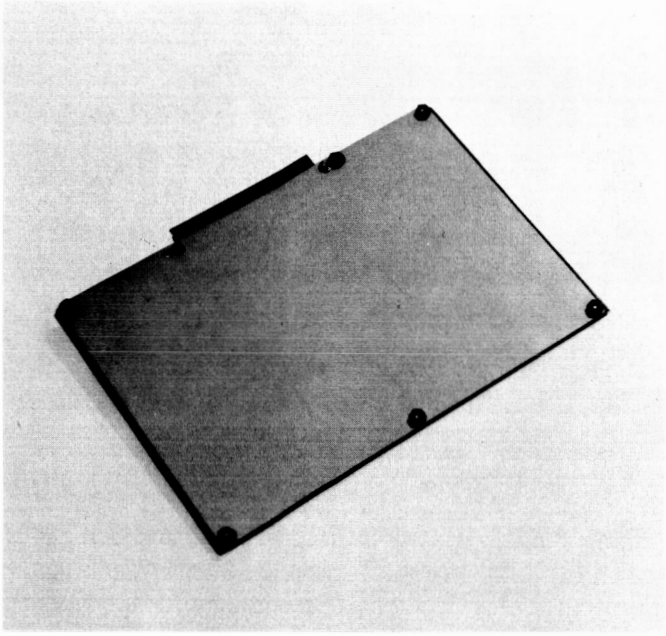

Fig. 13. Standard card, special purpose

D. Subchassis

The subchassis, shown mounted on the standard chassis in Fig. 2, is shown in Fig. 14. It is designed to hold heavy components and is removable from the standard chassis by disconnecting the subchassis umbilical cable and removing the mounting bolts.

As with the other parts of the design, the dimensions can be varied for a particular application. To accommodate changes, dash numbers must be added to the standard drawing, as explained in the Appendix.

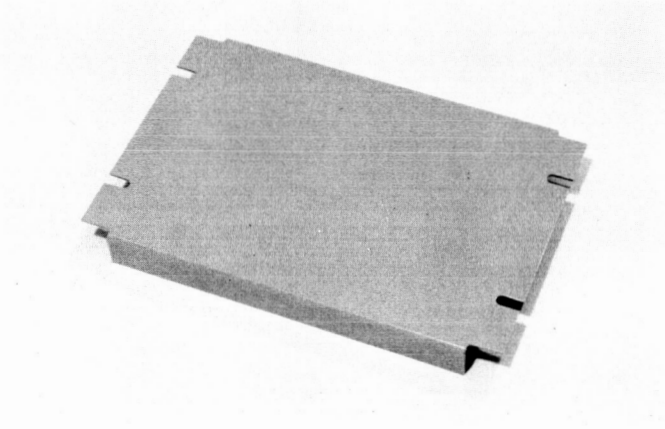

Fig. 14. Standard subchassis

V. CONCLUSIONS

This standardization of a basic chassis, logic card file, special purpose card file, and subchassis is a particular approach to one of the problems associated with the development of prototype equipment. The solution recommended is a tool that can be used for producing more reliable, less costly electronic systems on schedule. There are many ways in which the items which were discussed may be adapted, but before any modifications are attempted the following basic design philosophy should be considered:

1. If existing parts can fulfill the requirements, they should be used.
2. If modifications are definitely necessary, maximum use should be made of existing parts.
3. If modifications are required, maximum use should be made of existing drawings.
4. Redesign should be kept to a minimum.
5. Simplicity should be an important design criterion.
6. The cost of modifications or redesign should be kept to a minimum.

The design approach described in this memorandum has proved successful. Costs of the chassis and its associated parts are commensurate with similar commercial items and, in some cases, significantly lower. Flexibility and rapid assembly time are outstanding among the desirable features that have been realized.

VI. GENERAL

The manner in which a power supply, developed commercially, was packaged on the standard chassis is shown in Figs. 15 and 16. Since the parts for the standard chassis were available, they were sent to the manufacturer who packaged the power supply, eliminating the cost of a mechanical design effort.

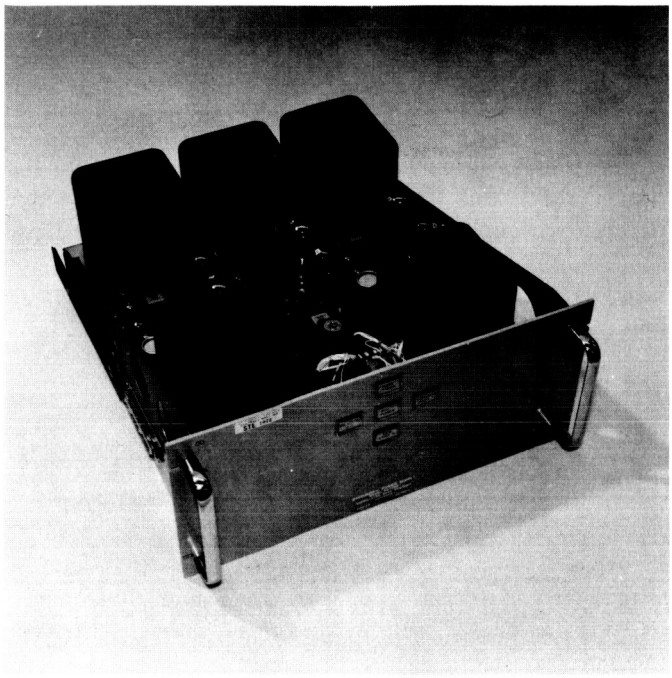

Fig. 15. Power supply, front view

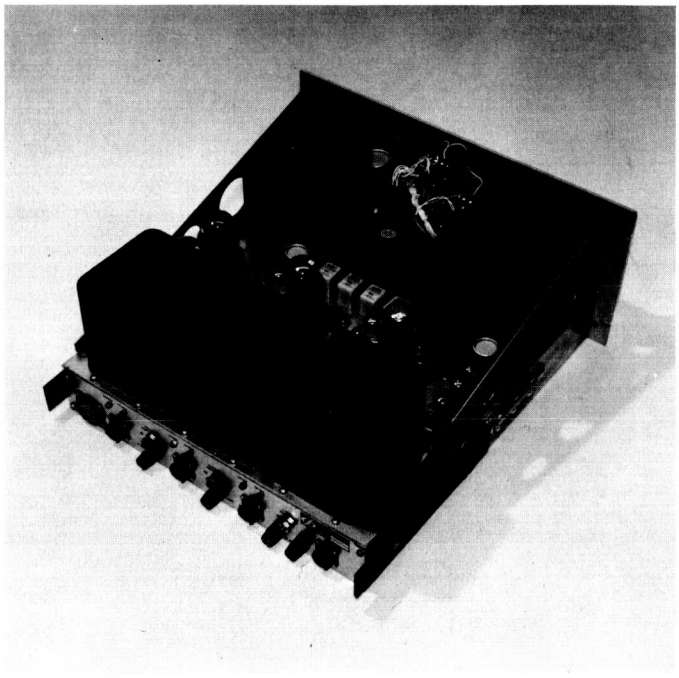

Fig. 16. Power supply, rear view

APPENDIX

Examples of Standard Chassis Drawing Change Procedures

I. METHOD FOR MODIFYING LOGIC CARD FILES (EXAMPLE 101)

Requirements

1. Number of cards = 8
2. Card width = 5.5 in.
3. Card height = 7.750 in.
4. File mounting = 1.000 in. from side

Assumptions

1. Card thickness = 0.250 in.

Solution

A. Modify Rail Guide, Card File (Logic), drawing number D123140

Step 1. Add the next dash number to the tabulation block (dash number "N").

Step 2. Add the number of slots (8) to the proper column of the tabulation block.

Step 3. Add the number of equal spaces (7) to the proper column of the tabulation block. (Since the last slot is not included in the C dimension, only 7 spaces are required to determine dimension C.)

Note: If a logic card width (ΔL) and/or spacing between cards (ΔLL) is to be changed, a new drawing must be provided. The dimension of the logic card slot (0.260 inches) on the new drawing and the reference dimension (0.932 in.) must be changed by an amount ΔL and/or the space between slots (0.609 in.) changed by an amount ΔLL.

Step 4. Determine dimension C.

C = number of equal spaces $\times$ 0.609 in.
$C = 7 \times 0.609$
$C = 4.263$ in.

Step 5. Determine dimension B.

$B = C + 0.406 + 0.932$
$B = C + 1.338$
$B = 4.263 + 1.338$
$B = 5.601$ in.

Note: If the slot dimension changes from 0.260 by ΔS, then dimension 0.932 should be changed by ΔS or dimension B changed by ΔS.

Step 6. Determine dimension A.

$A = B + (2)(0.1875)$
$A = B + 0.375$
$A = 5.601 + 0.375$
$A = 5.976$ in.

Step 7. Add dimensions A, B, C to the tabulation block next to dash number "N."

Step 8. Change the information next to the correct "find number" on the drawing to be compatible with the new dimensions.

Step 9. Order parts to drawing number D123140-N.

B. Modify End Plate, Card File (Logic), drawing number D123141

Step 1. Add the next dash number to the tabulation block (dash number "N").

Step 2. Determine dimension A.

A = card width $-$(depth of one card slot + 0.021 tolerance)
A = card width $-(0.104 + 0.021)$
A = card width -0.125
$A = 5.500 - 0.125$
$A = 5.375$ in.

Step 3. Determine dimension B.

B = card height + 0.190
$B = 7.750 + 0.190$
$B = 7.940$ in.

Step 4. Determine dimension C.

C = card height -1.000
$C = 7.750 - 1.000$
$C = 6.750$ in.

Step 5. Determine dimension E (one end plate)
E = distance of card file mounting hole from the side
$E = 1.00$ in.

Step 6. Determine dimension F (reverse end plate)
F = distance of card file mounting hole from the side
$F = 1.000$ in.

Note: Since dimensions E and F are independently associated with either end plate, they may differ; however, they are normally the same.

Step 7. Determine dimension D.
$D = A - (2)E$ or $D = A - (2)F$
$D = 5.375 - (2)\,1.000$
$D = 3.375$ in.

Step 8. Add dimensions A, B, C, E to the tabulation block next to dash number "N."

Step 9. Add dimensions A, B, C, D, F to the tabulation block next to dash number "N + 1".

Step 10. Change the information next to the correct "find number" on the drawing to be compatible with the new dimensions.

Step 11. Order parts to drawing number D123141-N and D123141-(N + 1).

II. METHOD FOR MODIFYING SPECIAL PURPOSE CARD FILES (EXAMPLE 102)

Requirements

1. Number of cards = 6
2. Card width = 8.5 in.
3. Card height = 6.250 in.

Note: The minimum width of board that may be used in this file is 5.124 in.

Assumption

1. Card thickness = 0.062 in.

Solution

A. Modify Rail Guide, Card File (Special Purpose), drawing number D123155

Step 1. Add the next dash number to the tabulation block (dash number "N").

Step 2. Add the number of slots (6) to the proper column in the tabulation block.

Step 3. Add the number of equal spaces (5) to the proper column of the tabulation block. (Since the last slot is not included in the C dimension, only 5 spaces are required to determine dimension C.)

Note: If a different spacing between cards is to be used, a new drawing must be provided in which the dimension of the space between slots (1.562 in.) and the reference dimension (2.001 in.) are changed by an amount ΔL. The remaining dimensions, on the existing drawing, should not be changed.

Step 4. Determine dimension C.
C = number of equal spaces $\times$ 1.562 in.
$C = 5 \times 1.562$
$C = 7.810$ in.

Step 5. Determine dimension B.
$B = C + 0.625 + 2.001$
$B = C + 2.626$
$B = 7.810 + 2.626$
$B = 10.436$ in.

Step 6. Determine dimension A.
$A = B + 2(0.1875)$
$A = B + 0.375$
$A = 10.435 + 0.375$
$A = 10.810$ in.

Step 7. Add dimensions A, B, C to the tabulation block next to dash number "N".

Step 8. Change the information next to the correct "find number" on the drawing to be compatible with the new dimensions.

Step 9. Order parts to drawing number D123155-N.

B. Modify Terminal Board Blank (Special Purpose), drawing number D123157

Step 1. Add the next dash number to the tabulation block (dash number "N").

Step 2. Determine dimension A.
A = Card width
$A = 8.5$ in.

Step 3. Determine dimension B.
B = Card height
$B = 6.250$ in.

Step 4. Determine dimension C.
$C = A - 0.625$
$C = 6.250 - 0.625$
$C = 5.625$ in.

Step 5. Determine dimension D.
$D = C/2$
$D = 5.625/2$
$D = 2.813$ in.

Step 6. Determine dimension E.
$E = B - 2(0.1875)$
$E = 5.845 - 0.375$
$E = 5.470$ in.

Step 7. Add dimensions A, B, C, D, E to the tabulation block next to dash number "N".

Step 8. Change the information next to the correct "find number" on the drawing to be compatible with the new dimensions.

Step 9. Order parts to drawing number D123157-N.

C. Modify Stiffener, Terminal Board (Special Purpose), drawing number D123158

Step 1. Add the next dash number to the tabulation block (dash number "N").

Step 2. Determine dimension A.
A = Card width $- 0.250$
$A = 8.500 - 0.250$
$A = 8.250$ in.

Step 3. Determine dimension B.
B = Card height $- 0.405$
$B = 6.250 - 0.405$
$B = 5.845$ in.

Step 4. Determine dimension C.
$C = A - 2(0.1875)$
$C = A - 0.375$
$C = 8.250 - 0.375$
$C = 7.875$ in.

Step 5. Determine dimension D.
$D = C/2$
$D = 7.875/2$
$D = 3.938$ in.

Step 6. Determine dimension E.
$E = B - 2(0.1875)$
$E = B - 0.375$
$E = 6.250 - 0.375$
$E = 5.875$ in.

Step 7. Add dimensions A, B, C, D, E to the tabulation block next to dash number "N".

Step 8. Change the information next to the correct "find number" on the drawing to be compatible with the new dimensions.

Step 9. Order parts to drawing number D123158-N.

D. Modify Support End, Card Holder (Special Purpose), drawing number D123156

Step 1. Add the next dash number to the tabulation block (dash number "N").

Step 2. Determine dimension A.
A = Card width $-$ (depth of one card slot + 0.031 tolerance)
A = Card width $- (0.094 + 0.031)$
A = Card width $- 0.125$
$A = 8.5 - 0.125$
$A = 8.375$ in.

Step 3. Determine dimension B.
B = Card height $+ 0.160$
$B = 6.250 + 0.160$
$B = 6.410$ in.

Step 4. Determine dimension C.
C = Card height $- 1.030$
$C = 6.250 - 1.030$
$C = 5.220$ in.

Step 5. Determine dimension D.
$D = A/2$
$D = 8.375/2$
$D = 4.188$ in.

Step 6. Determine dimension E.
$E = D - 0.905$
$E = 4.188 - 0.905$
$E = 3.283$ in.

Step 7. Add revised card file end plate dimensions *A, B, C, D, E* to the tabulation block next to dash number "N".

Step 8. Change the information next to the correct "find number" to be compatible with the new dimensions.

Step 9. Order parts to modified end plate drawing number D123156-N.

III. METHOD FOR MODIFYING SUBCHASSIS (EXAMPLE 103)

Requirements

1. Subchassis length = 11 in.
2. Subchassis width = 6.5 in.
3. Flange depth = 2.0 in. (for protection of components extending below the chassis).
4. Subchassis mounting = 1.5 in. from side.

Note: The maximum flange depth must not exceed 3 in. since the basic chassis on which the subchassis is mounted is only 3 in. deep.

Solution

A. Modify Subchassis, drawing number D123159

Step 1. Add the next dash number to the tabulation block (dash number "N").

Step 2. Determine dimension *A*.
A = Subchassis length
A = 11 in.

Step 3. Determine dimension *B*.
B = Subchassis width
B = 6.5 in.

Step 4. Determine dimension *C*.
C = Distance of subchassis mounting holes from the side
C = 1.500 in.

Step 5. Determine dimension *D*.
$D = B - (2)C$
$D = 6.5 - (2)(1.5)$
$D = 6.5 - 3.0$
$D = 3.5$ in.

Step 6. Determine dimension *E*.
E = Depth of flange
E = 2.0 in.

Step 7. Add revised card file end plate dimensions *A, B, C, D, E* to the tabulation block next to the dash number "N".

Step 8. Change the information next to the correct "find number" on the drawing to be compatible with the new dimensions.

Step 9. Order parts to modified end plate drawing number D123159-N.

Table A1. Formulas for modifying drawings of standard chassis

I. CARD FILES (LOGIC)	II. CARD FILES (SPECIAL PURPOSE)
D123140—Rail Guide A = B + 0.375 B = C + 1.338 C = (number of cards − 1) × 0.609 D123141—End plate A = Card width − 0.125 B = Card height + 0.190 C = Card height − 1.000 D = A − 2E or D = A − 2F E = Distance of card mounting hole from the side F = Distance of card mounting hole from the side	D123155—Rail Guide A = B + 0.375 B = C + 2.626 C = (Number of cards −1) × 1.562 D123157—Terminal board blank A = Card width B = Card height C = A − 0.625 D = C/2 E = B − 0.375 D123158—Stiffener, terminal board A = Card width − 0.250 B = Card height − 0.405 C = A − 0.375 D = C/2 E = B − 0.375 D123156—Support End A = Card width − 0.125 B = Card height + 0.160 C = Card height − 1.030 D = A/2 E = D − 0.905
III. SUBCHASSIS	
D123159—Subchassis A = Subchassis length B = Subchassis width C = Distance of subchassis mounting holes from the side D = B − 2C E = Depth of flange	

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